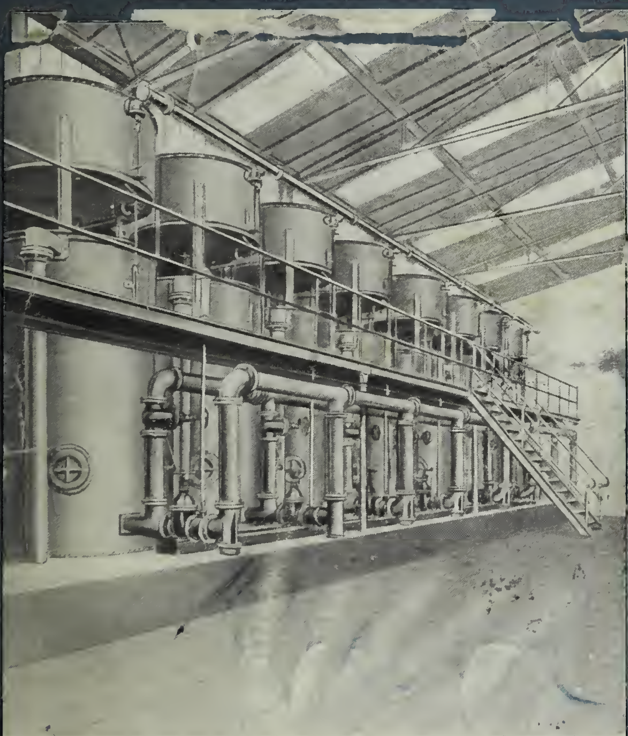
Permutit

PERMUTIT



A PERMUTIT PLANT TREATING 1,000,000 GALLONS PER DAY OF WATER FLUCTUATING BETWEEN 14 AND 21 GRAINS PER GALLON OF INCRUSTING SOLIDS, WHICH ARE COMPLETELY REMOVED

THE PERMUTIT COMPANY
30 EAST 42D STREET
NEW YORK

PERMUTIT

What It Is:

It is the Best and Most Efficient
Water Treatment

What It Does:

Removes All Hardness from Water
Removes Iron from Water
Purifies Water

Gold Medal Awarded at the International
Exhibition of 1913, Ghent, Belgium

THE PERMUTIT COMPANY
30 EAST 42D STREET, NEW YORK CITY

The desirability of good water for all purposes is recognized everywhere.

Municipalities, manufacturers, railroads and other steam users, laundries and households, in fact, all users of water, are constantly confronted with this problem. Their complaints are as manifold as the devices which have been suggested and tried to improve the quality of water, but it was not until Professor Robert Gans brought out his famous suggestion of using Zeolites for water treatment and when he then further proceeded in his efforts and succeeded in producing artificial zeolites, which he named Permutit, that we found the ideal process for treating water.

It makes hard water absolutely soft; removes iron and manganese completely, and forms the long sought for missing link in modern sterilization.

The apparatus resembles in appearance a filter and its operation is perfectly simple and entirely automatic.

The Permutit Process combines, therefore, highest efficiency with greatest simplicity. No better proof of its wonderful merits could be given than by referring to the many thousands of Permutit plants which are being successfully operated all over the world. The rapid growth in the number of installations in this country speaks for itself.

WHAT IS PERMUTIT?

Permutit is a granular porous mineral compound with pearl-like lustre. It is an artificial zeolite which like these, possesses the property of exchanging its chemical base for another. The name is derived from the Latin word "Permutare" (to exchange, to permute). It is manufactured by fusing together feldspar, kaolin, pearlash and soda, in definite proportions.

BILTMORE HOTEL, NEW YORK
USING PERMUTIZED WATER THROUGHOUT HOTEL
INCLUDING THE SUPPLY FOR DRINKING,
BATHING, LAUNDRY, ETC.

THE PERMUTIT APPARATUS.

The apparatus is constructed similar to an ordinary sand filter but is filled with a layer of Permutit instead of sand. The sizes vary according to requirements, from a small household filter to larger sizes for industrial purposes and municipalities. It is one of the great advantages of the Permutit Process—that the apparatus is compact and can be installed even where space is limited.

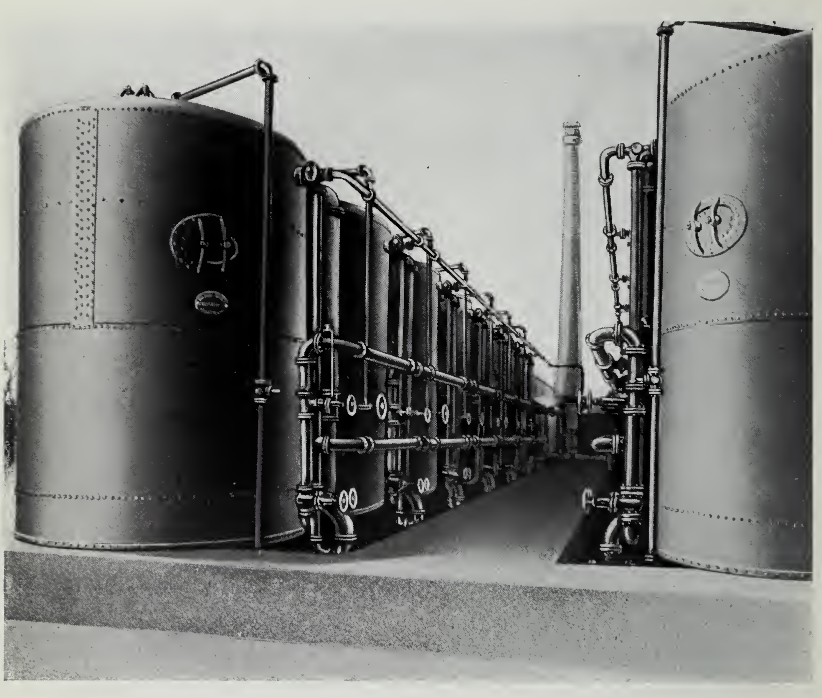
PERMUTIT FOR SOFTENING WATER.

Hard water is a constant source of annoyance and expense. It forms scale in steam boilers and pipes, spoils materials, and mars the quality of many manufactured products. The familiar sight of a barrel under the rain pipe in districts where the water is hard, is a proof of the necessity of soft water.

Lime and magnesia in varying combinations constitute the hardness of water. *The Permutit Softening Filter makes the hardest water absolutely soft.* It removes from the water every trace of lime and magnesia regardless of the quantity and combination in which they may be present. Using the rating of hardness in degrees, as employed in most foreign countries, this means that a water of say 10 degrees hardness is reduced to zero degrees by entirely automatic means and independent of any variation in hardness that may occur at any time. No other process can achieve such results. All other systems, apart from requiring constant and careful expert attention, leave, under the best conditions, enough hardness in the water to cause serious troubles.

The material used in a softening filter is Sodium Permutit, so named because its chemical base is Sodium. By the power of "base exchange," which Permutit possesses, both the calcium and magnesium are absolutely extracted from the water as soon as it comes into contact with Permutit; their place is taken by the Sodium in the Permutit, leaving in the softened water a precisely equivalent amount of Sodium Salts to that of Calcium and Magnesium in the original crude water. An "over—or under-treatment" as well as "after reactions" are thus automatically prevented, and as no sludge of any sort is produced, the water remains always perfectly clear. Naturally the time will come when the Sodium in the Permutit becomes exhausted, but here again the "exchange principle" is applied, the action merely being reversed. The Permutit is restored to its original strength by passing through it a solution of Sodium Chloride, which is,

common salt. The Permutit is thus rejuvenated into its original efficiency *without any deterioration whatsoever*, and this process can be repeated for an indefinite period. This rejuvenation, or regeneration, is a very simple matter, being accomplished by allowing the salt solution to flow into the filter at night, or any other time when the filter is not in use. About 8



MUNICIPAL PLANT FOR SOFTENING THE WATER SUPPLY OF HOOTON, NEAR LIVERPOOL, ENGLAND

or 10 hours later, this salt solution is drained off, and this, being a perfectly clear and harmless liquid, can be run into any drain pipe.

When a constant supply of soft water during the 24 hours of the day is required, the plant is divided into two smaller units which are operated alternately for 12 hours each. Under certain conditions it is preferable to use storage instead, and draw from this as required.

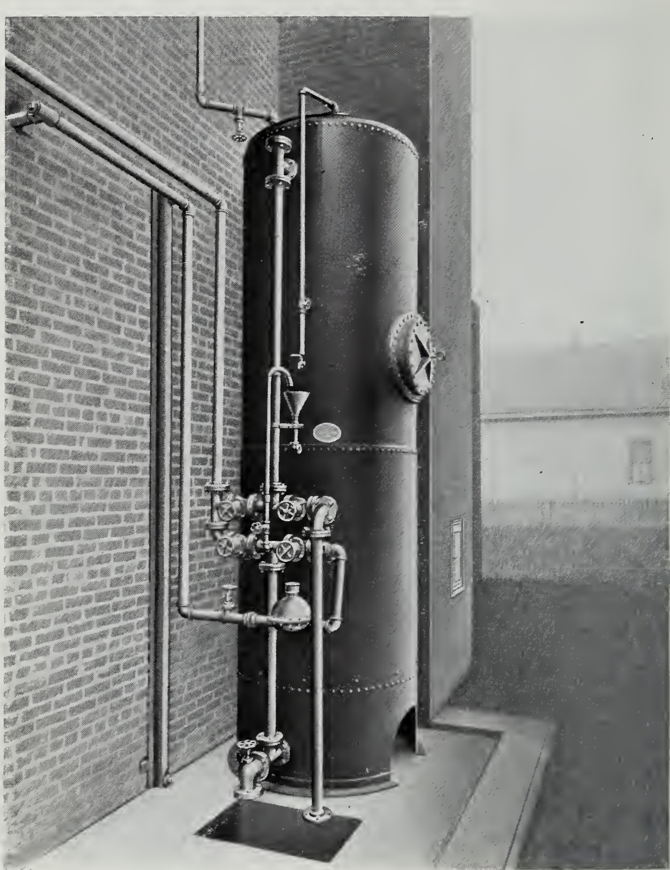
SOFT PERMUTIZED WATER FOR STEAM BOILERS.

Prevention of Scale.—Every user of steam power knows the effect of hard water in a boiler. It forms scale, and scale is the worst enemy of efficiency. The heat loss through scale is disproportionately large as the thickness of the scale increases, and careful experiments have demonstrated that even a thin coat of scale will increase the fuel consumption by 20 per cent. and more. Scale is furthermore the cause of costly repairs and makes frequent boiler cleaning necessary.

It is obvious that water which is free from scale forming matter will eliminate all wastage and trouble. This ideal feed water is obtained by the Permutit Softening Process only. *We guarantee that boiler scale is entirely eliminated.*

Pitting.—Water containing chlorides and particularly magnesium chloride, is dangerous for boiler feed because magnesium chloride, for instance, will, when subjected to a high temperature, split off hydrochloric acid and this is the most dangerous pitting agent. The Permutit treatment prevents this because it converts the magnesium chloride into sodium salt, which cannot liberate acids.

Carbonic acid which is liberated from the temporary hardness of a water in the boiler may be considered as harmless; though the carbonic acid is driven off, it is instantaneously diluted and is carried over with the steam.



A PERMUTIT WATER SOFTENER AT A LAUNDRY,
BUFFALO, N. Y.

TEXTILE INDUSTRY.

The presence of Calcium and Magnesium Salts in water is responsible for the chief difficulties which the silk and wool men encounter in washing, steeping, degumming, dyeing, bleaching and finishing materials and goods. In the first place, in washing raw silk and raw wool an excessive amount of soap is required to overcome these salts in the water. The soap compounds thus formed, collect in small deposits on the surface of the materials and are impossible to remove. When the dyer undertakes his work these deposits cause spots and blemishes, unevenness in dyeing so that the general effect of the colors is not as clear and vivid as it should be.

Dyeing is a process which involves many very delicate reactions and only the best and softest water should be used in mixing the colors. Many aniline colors dissolve badly in waters containing lime. The colors of cochineal, methyl blue, etc., are materially altered by the presence of hardening constituents and as hard water often fluctuates in degrees of hardness, the matching of delicate colors is a matter of much difficulty. In madder-dyeing hard water not only causes variations in shades, but may cause precipitates which produce spots on the goods.

In woolens the dyeing is not only improved by the use of soft water, but the finished goods are rendered soft and delicate to the touch. By washing wool in Permutized water a larger percentage of higher grades is obtained than usual. This has been proved by users of Permutized water, as for instance, the Bradford wool-combers of England, and many others. Besides the irregular and uneven shading caused by the use of hard water, the weighting of silk is made most unsatisfactory. The tin does not adhere uniformly to the silk owing to the lime and magnesium soap-precipitates that have been formed. The great success of the French silk industry is mostly due to the softness of the water used, a fact admitted by the manufacturers. Nevertheless, the largest French silk houses have installed the Permutit process to remove even the small degree of hardness present in the water.

Water containing iron is most disastrous to the textile industry and the method of removing this by Permutit will be found on page 13.

LAUNDRY.

The soap consumption is of utmost importance to laundrymen. The harder the raw water, the more soap is wasted, as it will not produce any suds until all the soluble hardening salts have been precipitated in the form of insoluble lime and magnesium soaps. Experience shows that for each degree of hardness, 1½ pounds of soap are destroyed per thousand gallons of water. Assuming for instance, that the water is 10 degrees hard and 20,000 gallons are used in the suds, there is a waste of 300 pounds of soap. It requires an excess of soap over this amount to form suds.

A COMBINED PERMUTIT IRON REMOVAL AND SOFTENING PLANT

Besides the pecuniary loss there is another important factor to consider, that is the effect of these insoluble soap compounds on the linen itself. They are precipitated in the fibres and adhere so strongly, that they remain there in the greatest part, even after the final rinsing. They make the fibers brittle and produce after a while a rancid odor due to decomposition, and further, an irregular and uneven color in the process of ironing. Linen washed in Permutized water is delightfully soft and white in appearance.

THE CANNING INDUSTRY.

A delicious tenderness of meats, fruits and vegetables can not be obtained but by using soft water. The lime and magnesium salts, which constitute the hardness of the water, form in the process of boiling, fine deposits on the products. An extensive experience has proved that the boiling is completed in half the time if Permutized water is used. This involves a great saving in time and expense.

TANNING INDUSTRY.

The unhairing of the skin is done by loosening the roots of the hair by saponifying with quick lime the greasy matter secreted by the small hair glands. If the water contains a large amount of lime, some of this is precipitated on the dermal tissue. This deposit interferes with the absorption of the tannin in the cells of the hide and causes brown stains to appear on the leather.

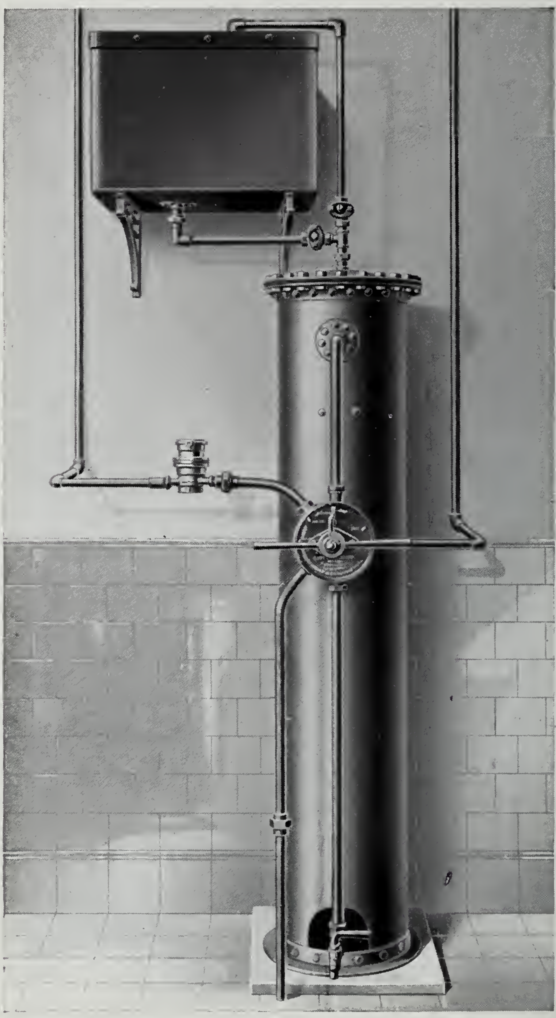
PAPER MANUFACTURING.

Hard water is unsuited for paper-making for several reasons. It interferes with the sizing used on the paper and has an important effect on dyeing; iron salts especially are objectionable in a paper-mill, because they give rise to brown spots and streaks. Hardness affects the process of paper-making in another way. The paper-pulp is carried over two sheets of wire gauze, and if lime is present in the water, the pores of the wire gauze are likely to become choked up with what is called "Water stone," which is really nothing else than calcium carbonate.

VARIOUS INDUSTRIES.

The advantages of perfectly soft water as produced only by the Permutit Process, will appeal to a great number of water users, particularly to those who use chemicals of any kind. As for instance, in the manufacturing of soap, in printing, distilling, photography, ice making, bottling, etc.

We shall always be glad to furnish any information concerning the effect of Permutized water on any particular branch of industry.



TYPE OF WATER-SOFTENING FILTER
FOR HOUSEHOLDS

SOFT WATER FOR HOUSEHOLDS.

"Our water is good, but it is hard!" we hear people say so often. Here is the only apparatus which you can install in your home regardless of its size, and which will make the hardest water as soft as rain water. Permutized water is delightfully smooth and velvety for bathing, shaving and shampooing. Rough skin is entirely avoided and chapped hands are made impossible. It is matchless for the complexion and absolutely hygienic in its use.

The laundry is rendered snow white and soft, and the soap bill is materially reduced.

Soft water used in the kitchen saves labor and adds greatly to the flavor and tenderness of vegetables and other foods.

PERMUTIT FOR REMOVING IRON AND MANGANESE FROM WATER.

Permutit is not confined to water softening only. By means of a specially prepared Permutit it has become possible to *remove iron and manganese from water.* If these are present, the water is not only exceedingly objectionable for domestic supply, but in very many industries, altogether disastrous, as for example, in dyeing, laundries, paper mills, etc.

This class of Permutit has been named Manganese Permutit. It is charged with an extremely high amount of oxygen and therefore might be compared to a store-house of oxidizing material.

When filtering water through Manganese Permutit the iron or manganese is oxidized instantaneously and thrown into suspension. The Permutit layer itself, works as a mechanical filter and retains the iron and manganese within the filter. The process is extremely simple and reliable. Large municipalities, as for instance, the City of Dresden in Germany, Hooten in England, and many others, treat their whole water supply by this system.

The efficiency of these filters is extremely high and regeneration need not take place but every three or four weeks; in some cases only at intervals of several months. It is effected by treating the Permutit with a solution of permanganate of potash.

THE PERMUTIT IRON REMOVAL FILTERS OF THE MUNICIPAL PLANT AT HOOTON, ENGLAND

PERMUTIT IN THE STERILIZATION OF WATER.

The water treatment for sterilization is subject to different conditions and a modification of our general rule may under circumstances be desirable. It is here proposed to explain on broad lines our system, and to show the immeasurable merit of Manganese Permutit in sterilization.

The following is the process which we recommend for treating contaminated water containing suspended matter. It eliminates the bacillus Coli completely, and in addition, the bacteria are reduced to practically nothing. The water obtained is beautifully clear and palatable and of a blue-white color.

Chlorine is introduced into the contaminated water after which provision is made for a contact period between the water and the chlorinating solution. Thereafter there is introduced into the water a solution of an iron salt which reacts with the chlorine in the water and entirely eliminates all free chlorine, this being taken up in process of converting the iron salt into a higher oxide. Subsequently there remains only the removal of the iron. This is effected by allowing the water to flow through a filter containing Manganese Permutit which removes the iron.

The water which is finally delivered is thoroughly sterilized and free from either chlorine or iron. The plant for carrying out this process is very simple, no moving parts whatever entering into the operation. The only requisite is to keep the store tanks of treating solutions supplied and to backwash the Permutit filter for a few minutes at certain intervals depending on the quantity of iron and suspended matter to be removed.

In cases where the water is clear but is contaminated by germs, the process can be simplified in the following manner. The water is chlorinated and then passed through a Manganese Permutit Filter which will destroy and collect all the germs. The hypochlorates introduced in this process are entirely eradicated by the Manganese Permutit. The water then delivered is free from germs, odorless and free from the objectionable taste of chlorine, this having been entirely eliminated.

A PERMUTIT SOFTENING PLANT IN BROOKLYN, N. Y.
TREATING 160,000 GALLONS OF WELL WATER
PER DAY. RAW WATER 25° HARDNESS

THE COST OF INSTALLATION.

This depends on the composition of the water and the quantity to be treated. As conditions vary practically with each case we must confine ourselves to giving below a price list of water softening installations for households only. *It would be entirely misleading to attempt to base a calculation for larger plants on these figures.*

The Permutit Company has a large staff of engineers and chemists whose services are always free to any one who wishes specific information on this or other points. (See list of questions on last page.)

TABLE I

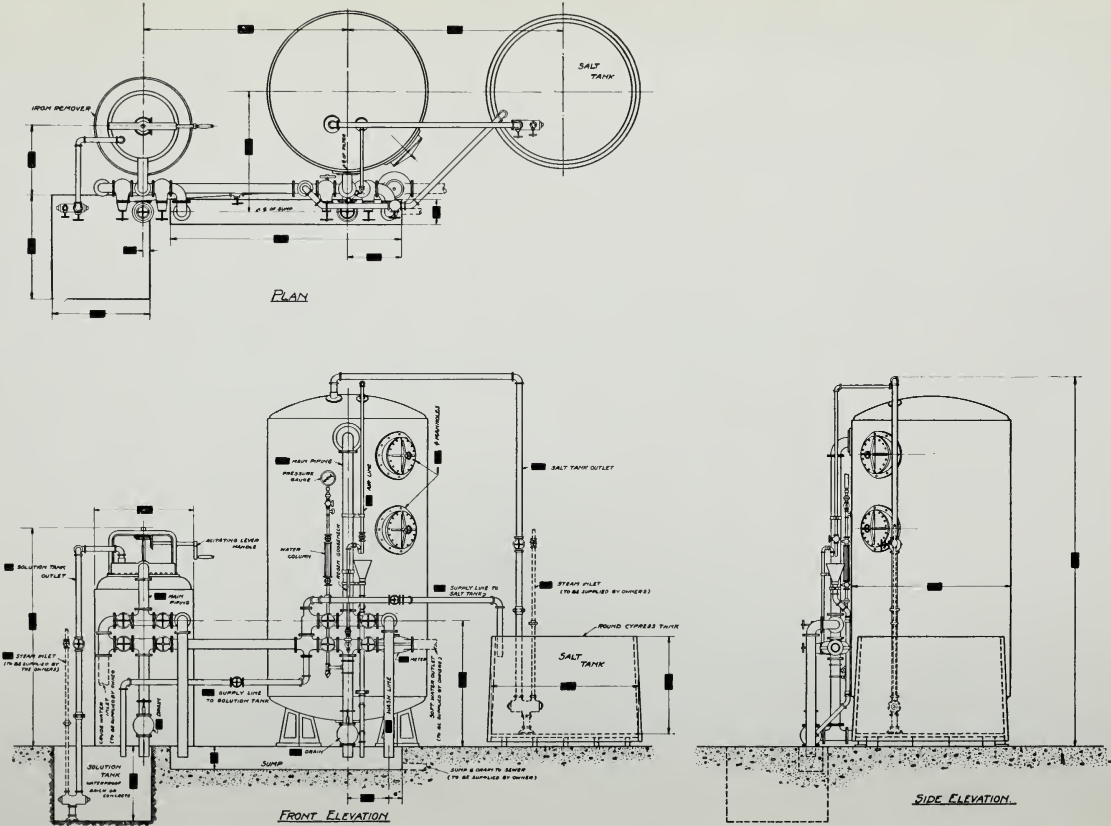
CAPACITIES IN U. S. GALLONS

Between Regenerations and Maximum Rate Per Minute.

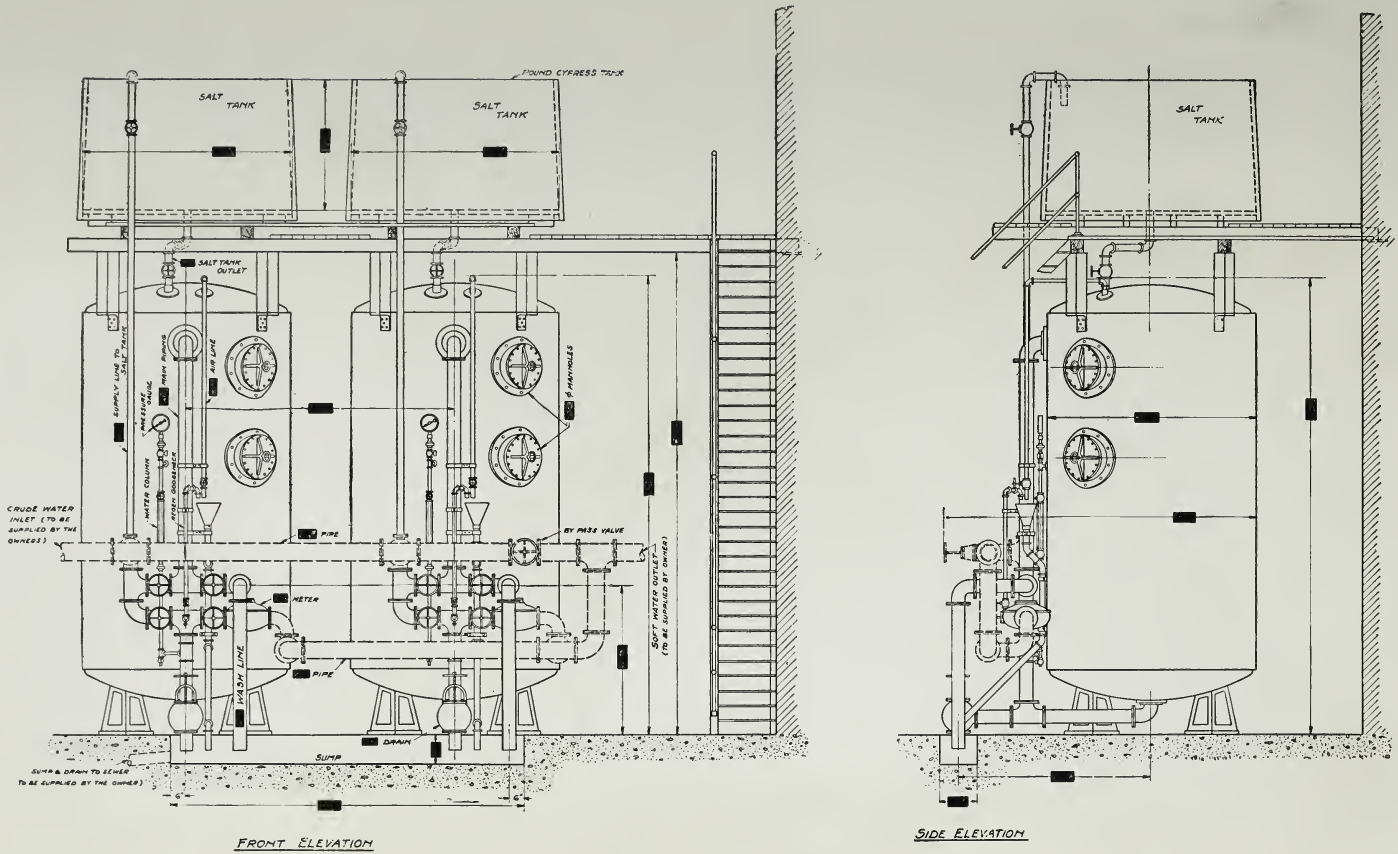
H=	5°		10°		15°		20°		
Serial No.	Gals. Per Minute.	Total Gallons.	Gals. Per Minute.	Total Gallons.	Gals. Per Minute.	Total Gallons.	Gals. Per Minute.	Total Gallons.	Price.
A-1.......	.6	140	.3	60	.2	30	.2	20	$ 50
A-3.......	1.4	755	.7	355	.5	220	.4	155	170
A-4.......	2.6	1,730	1.3	820	.9	520	.6	370	250
A-5.......	5.8	3,890	2.9	1,845	2.0	1,170	1.4	830	450
A-6.......	7.9	5,310	3.9	2,515	2.7	1,600	2.0	1,135	550
A-7.......	10.3	6,935	5.1	3,290	3.5	2,075	2.6	1,475	750

5° medium hard. 20° very hard.

A storage tank for soft water will in most cases be advantageous because the output from the filter can accumulate there at a lower rate per minute than is actually used when filling the bath, etc.



A LAYOUT OF COMBINED IRON REMOVAL AND SOFTENING FILTERS



A LAYOUT OF A TWO UNIT SOFTENING PLANT

COST OF OPERATION.

Softening Filters.—The cost of salt which is used for regenerating practically covers the cost of operation, as the filters work automatically and attendance is reduced to a minimum and can be easily taken care of by the existing labor. The price of salt is the important factor. It varies considerably in different localities from as low as \$1.50 per ton, up to \$7 and \$8. Assuming, for example, that an installation is designed to treat a water containing 175 parts per million of lime salts, and further that salt costs \$4 per ton, then the cost of operation will be equivalent to 2 1-3 cents per thousand gallons of water, and at other prices, correspondingly lower or higher.

Iron and Manganese Filters.—The efficiency of these filters is extremely high and regeneration need not take place but every three to four weeks, in some cases only at intervals of several months, and taking the average price of the regenerating medium (Permanganate of Potash) to be 10 cents per pound, as a basis, the operation will cost from 7 cents per million gallons upwards. This is very low indeed.

Please Answer these Questions as far as possible and forward

We shall then supply you with detailed information regarding the use of PERMUTIT as applied to your particular requirements.

THE PERMUTIT COMPANY

30 EAST FORTY-SECOND STREET
NEW YORK

*Date*________________________

*Name*____________________________________

*Address*____________________________________

1. Source of water supply? (Lake, pond, well or municipal).	
2. Is the water clear all the year around?	
3. Have you either a filtering or softening plant? Description?	
4. Maximum quantity of water used per day of..................working hours?	
5. What is the maximum hourly consumption during peak hours?	
6. What working pressure would filter be required to withstand?	
7. Purpose for which treated water is to be used?	
8. Capacity of storage tank? Height of storage tank? Elevation of storage tank above proposed site of filter?	
9. Have you a recent complete reliable analysis of the water to be treated? If composition of water varies, send analyses covering all seasons of year, or analysis of water of maximum hardness.	

[OVER]

10. Please send prepaid a sample (at least ½ gallon, preferably a gallon) of the water for our examination. The sample should be taken in a glass container, which has first been carefully rinsed in the water in question. Seal the bottle and pack carefully for shipment to prevent breakage. Label bottle with your name before packing it.	
11. Description of pumping equipment to be used with proposed filter?	
12. Maximum rated capacity of pumping equipment?	
13. Actual maximum discharge of pumping equipment?	
14. Give dimensions and sketch of ground space and headroom available.	

If the Treated Water is to be Used for Boiler Feed, Please Supply the Following Additional Information

15. Rated H. P. of boiler?	
16. Actual total H.P. developed?	
17. Working pressure?	
18. Number of hours boilers are operated?	
19. How often and how much are boilers blown off?	
20. How often are boilers cleaned?	
21. How thick is the scale and what is the nature of it?	
22. Does your water foam or prime?	
23. Is there any pitting or corrosion?	
24. Do any traces of oil get in the boilers?	
25. What is the maximum amount of make-up water, if returns are used for boiler feed?	

The CHEMISTRY of PERMUTIT

zero
NO
HARDNESS
water

Reserve

THE PERMUTIT COMPANY
30 EAST 42ND STREET
NEW YORK

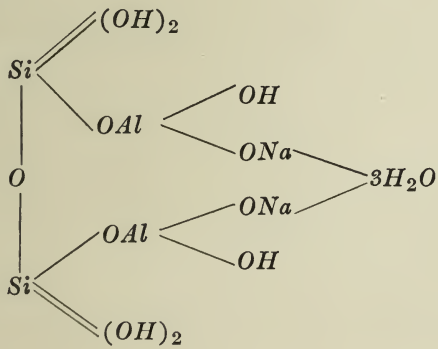
The Chemistry of Permutit

TO CLEARLY understand the following methods it may be mentioned that by the term "zeolites" we understand silicates containing water, which, in contradistinction to other silicates occurring in nature, decompose and are soluble in dilute acids. They are combinations of aluminum and other bases with silicic acid, which possess the property of exchanging their bases for others.

The zeolites differ essentially from other silicates in that the bases contained therein, potassium, sodium, calcium, etc., are attached to the silicic acid through the medium of the aluminum radicle. Accordingly the empirical formula of an artificial zeolite, which is approximately as follows:—

$$2SiO_2\ Al_2O_3\ Na_2O\ 6H_2O$$

might be theoretically represented by the following formula:—



The remarkable linking of the bases in the zeolite molecule will be apparent from the above formula.

The essential properties of zeolite have to a great extent been expounded by Professor Gans in his treatise

on "artificial" zeolites or Permutit, so that these artificial zeolites have become of great value, particularly in the purification of water.

In the following, reference is particularly made to these properties, and observations are recorded which have been collected from experience gained in the investigation of such materials.

Composition of Permutit

The substance known as sodium Permutit is, in the moist condition, of a granular or flaky form, and has a lustre like that of mother-of-pearl, and is of an extremly porous nature.

Permutit is obtained by fusing together felspar, kaolin, pearlash and soda in definite proportions, and is for the purpose of hydration and for the removal of soluble silicates, lixiviated with hot water, the Permutit in its characteristic form being left behind as a residue. The slight residual alkalinity, due to the soda used in the manufacture, disappears after the first regenerations, *so that water is obtained which is entirely neutral to phenolphthalein.*

Chemical Process

One of the most important applications of sodium Permutit is its employment for *softening water used for industrial purposes.*

The total hardness of water consists of temporary hardness and permanent hardness. The former consists of calcium and magnesium bicarbonates, which, on boiling the water, are precipitated as insoluble carbonates, particularly the calcium, while the sulphates of lime and magnesia on boiling remain dissolved and constitute the permanent hardness of the water. When

the whole of the sodium contained in the Permutit has been exchanged against the calcium and magnesium contained in the water, regenerating or revivifying is necessary, which action is later fully described.

For convenience the Permutit radicle is indicated by P, and the softening of water takes place in accordance with the following equations:—

$$
\begin{aligned}
P - Na_2 + CaH_2(CO_3)_2 &= P - Ca + 2NaHCO_3 \\
P - Na_2 + CaSO_4 &= P - Ca + Na_2SO_4 \\
P - Na_2 + MgH_2(CO_3)_2 &= P - Mg + 2NaHCO_3 \\
P - Na_2 + MgSO_4 &= P - Mg + Na_2SO_4
\end{aligned}
$$

Similar chemical exchanges are observed in all other combinations of calcium and magnesium.

From the equations it will be seen that the operation is one of pure stoichiometry and is strictly within the limits of the equation. The temporary hardness of the water, due to the presence of calcium and magnesium bicarbonate, is removed by the formation of sodium bicarbonate, whereas the permanent hardness, including gypsum hardness, is removed by the formation of equivalent sodium salts.

Durability of Permutit

From the foregoing it follows that Permutit does not transfer to the water any soluble components such as alkaline silicates and aluminates, and only takes part in the interchange process by means of its basic radicles.

As it follows from the above that Permutit does not transfer any of its soluble components to the water, an unlimited durability and effective action of the Permutit can be assumed. From experience such an assumption is fully warranted and the only possible loss would be due to improper flushing or agitating of the Permutit.

Agitating the Filters

Before going further into the theory of regeneration, a few essential points relating to the technic of the operation may with advantage be mentioned. According to our experience the filtration through the Permutit is more effective from top to bottom than in the reverse direction. As it is natural for the material to gradually cake together, the necessary agitating before every regeneration is to loosen the Permutit mass and to remove any air or channels which may have collected or been formed in the filter. The agitating takes place from bottom to top, and the material is thoroughly loosened by the flushing and whirling action of the upward flowing water.

To prevent any loss during this action, a rising space is provided above the Permutit, and a layer of gravel resting on perforated plates placed between the top of the Permutit and the overflow.

Rate of Filtration

The slower the water passes through the Permutit mass, the better the interchange which takes place. In practice, a velocity of 10 to 15 feet per hour has been found the most suitable for obtaining good results with comparatively thin layers. If the layer of Permutit is made deeper the rate of filtration can be increased under certain conditions when the water is not too hard. The thickness of the layers, the rate of filtration, and the hardness bear a certain relation to each other for each kind of water treated, and form the basis in designing the filters. The rate of filtration determined for a particular filter should not be exceeded, since the exchanging capacity of the material would be reduced and the filter would become prematurely exhausted.

Regeneration of the Filters

The regeneration is according to the equation:—

$$P - Ca + 2\,NaCl = P - Na_2 + CaCl_2.$$
$$P - Mg + 2\,NaCl = P - Na_2 + MgCl_2.$$

From this equation it will be seen that for one molecule of CaO two molecules of $NaCl$ are required. This reverse reaction, however, follows the law of mass-action, and as calcium more readily combines with Permutit than sodium, it follows that for the regeneration more common salt is necessary than is required by the above equation.

In practice six to eight times as much common salt is employed for the regeneration of the filter, according to the hardness of the water, as CaO combines with the Permutit.

The salt is generally employed in a 10 per cent. solution for regeneration. The solution is introduced into the filter (from which the water has been previously run off to the layer of Permutit) and allowed to flow slowly through the filter from eight to ten hours. For the purpose of cleansing the Permutit of the salt solution, the filter is filled from the top with water, and the outlet cock is opened so as to allow the salty water to flow out for about ten or thirty minutes, slowly at first and then rapidly. The washing lasts until the water no longer shows any hardness with soap solution. For rinsing purposes, an average of 200 to 300 gallons of water for every 100 pounds of salt used can be reckoned.

Composition of the Water

The physical characteristics of the water to be filtered should be considered.

As already stated in the opening paragraphs, the Permutit is not only active at its surface, but also to the

centre of the grain, in consequence of its porosity. From this it follows that for the purpose of preventing a choking up of the pores of the Permutit, waters containing material amounts of suspended matter, such as iron, oil or clay must be clarified before treatment by the Permutit process, and acid waters must be previously neutralized.

Advantages of the Permutit Process

We beg to draw attention to a few of the many advantages that the Permutit Process possesses over other known systems of water softening:—

(1) Every water, however hard, may be reduced to 0 degrees of hardness simply by being passed through a layer of Permutit. No other process except distillation will accomplish this result.

(2) There is no addition of chemicals, but perfect automatic action without attention, giving invariably a water at 0 degrees hardness. Other systems all involve the use of chemicals, necessitating mechanical moving parts and proportional gear, requiring constant control by competent men, and, in the event of variation in the composition of the crude water, frequently result in an excess of lime and soda, or insufficient softening, or turbidity due to suspended lime.

(3) At no stage in the working is there any dirt or trouble from sludge. The periodical regeneration is accomplished by the addition of a clear, salt solution, and the resultant waste salty water is also perfectly clear and

fit to run direct into the drains. In other systems the original salts and the added chemicals are deposited together in a heavy precipitate, involving decanting reservoirs, filtration, and the subsequent digging out and carting away of the dried sludge.

(4) A Permutit plant takes up the least possible space, and can be designed with open top—*gravity system*—or with closed top—*pressure system*—with equal success.

Permutit for Removing Iron and Manganese from Water

We now come to the employment of a Permutit which does not act directly but only plays an important part as the intermediate carrier for certain reactions. If a suitable Permutit, such, for example, as sodium Permutit, is treated with a solution of manganous chloride, then, by double decomposition, a manganous Permutit and sodium chloride are obtained.

$$P - Na_2 + MnCl_2 = P - Mn + 2NaCl.$$

If such a Permutit which in appearance cannot be distinguished from other Permutits, be treated with a dilute solution of potassium permanganate, then an interchange of the bases and an oxidation of the manganese element takes place in accordance with the following equation:—

$$P - Mn + 2KMnO_4 = P - K_2MnO,Mn_2O_7$$

An oxidized product of manganese rich in oxygen is precipitated on the Permutit, the whole mass being colored deep brown. Now it is known that the most unstable peroxides of manganese in the presence of

oxidizable substances effect oxidation by giving off their oxygen in accordance with the equation:—

$$Mn_2O_7 = 2MnO + 5O.$$

This property, which is promoted by the large surface of the Permutit, is taken advantage of in practice. Such an action lasts, of course, until the oxygen of the manganese Permutit is exhausted. When it is exhausted, that is, when the aforesaid manganese Permutit has been completely reduced to

$$P — K_2,\ 3MnO,$$

then it must be re-oxidized, which operation is effected by solutions of potasium or calcium permanganate. As, however, by this reduction of the compound

$$P — K_2,\ MnO,Mn_2\,O_7 \text{ to } P — K_2(MnO),$$

three manganese atoms are to be oxidized, on its complete oxidation a compound would be formed having the following composition:—

$$P — K_2\ 3(MnO,\ Mn_2O_7).$$

Instead of the original five atoms of oxygen, such a compound would now contain 15 atoms of oxygen which can be disposed of. By reduction and re-oxidation in this manner large quantities of oxygen can be produced, so that it remains undecided whether the reduction is really to MnO or to MnO_2 or Mn_2O_3. This is of secondary importance for the elucidation of the operation. The reduction of such highly oxidized compounds can be conducted both by ferrous as also by manganous compounds, and by these reactions the sphere of utility of such Permutit is clearly defined. It is a well-known fact that many underground waters contain iron, and that the carbon dioxide or sulphuric acid, combined with the iron, are separated in the presence of air. These

precipitates cause numerous disadvantages: conduits are choked, and the water itself, which was originally clear, becomes turbid and of a slimy appearance, so that it is unfit for household and manufacturing purposes.

This more or less easy separation of the iron from the water in the presence of air constitutes a means for determining whether the iron can or cannot be readily removed from the water.

Springs which rise in underground moors or pass through moors or marshy districts, as also those which pass through districts containing putrefying matter and thus give off their oxygen, chiefly contain the iron combined with indefinable organic substances—humus acids—which obstinately retain the iron, and under ordinary circumstances do not allow of its separating out in the presence of air. It is only by means of protracted aeration in thin layers that a part of the iron can be removed from these waters, and then only because the organic substance is gradually consumed by the oxygen of the air. Such waters are easily recognized by their appearance. The color, according to the circumstances, varies from yellow to light-brown, and the smell is often moldy. A further characteristic of this kind of water is the very slight presence of minerals. The total hardness is generally very slight, and usually sulphates can hardly be detected, as the sulphates, when passing through a district containing putrefying matter are for the most part reduced. In the same manner as water containing iron in the presence of air enables us to estimate the difficulty of removing the iron from the water, the above features, *i. e.,* absence of sulphates, presence of ammonia or nitric acid, show the difficulties which must be overcome in removing the iron from the water. In such cases the water must be previously clarified, which process is later on more fully gone into.

We have seen that in some cases iron may be removed from the water by atmospheric influence; the removal of the iron from the water relates mainly to this procedure.

The first and oldest processes were based on the principle that water falling freely in the form of rain, as in the Oesten system, or trickling down, as in the Piefke system, over porous material, such, for instance, as coke, clay, sponge, gravel, and the like, was brought into intimate contact with the air. This "aeration" oxidized the iron, and the iron hydroxide then distributed in collodial form in the water, was separated out as a precipitate, and subsequently arrested by a filter. These installations have in course of time been found to have various disadvantages: apart from their usual large size and the corresponding large space required by the same, they also have the disadvantage that they are open to the air, and thus become soiled by mechanical and chemical impurities. In consequence of the ever-increasing demands of modern hygienics in respect to these installations, and especially of those cases which relate to the supply of potable water, it has become of late years, customary to construct these installations on the enclosed pattern. In this arrangement air is usually forced under pressure into the water through the pump delivery-pipe by means of a compressor, and the water thus laden with air was passed over a sand filter to arrest the separated iron slime. Opinions differ, however, as regards the amount of air to be pressed into the water. While, on the one hand, some state that, for the purpose of securing a removal of the iron as perfect as possible, it is necessary to press into the pipe large amounts of air. Others, on the other hand, believe that quite as good results can be obtained with very small amounts of air. It is not our intention to go into these contradictions. In accordance with another system the aerated water is

forced through closed filters, which are filled up with wood-wool, impregnated with ferrous hydroxide, stannic oxide, and other substances. The ferrous hydroxide is, before starting the operation, deposited on the wood-wool by causing ferrous sulphate and sodium carbonate, or ferrous chloride and caustic lime, to react on the fibre.

Although, according to both processes, good results can be obtained as long as the filters are properly attended to, *the separation of iron is never complete.* The addition of atmospheric oxygen does not always suffice for the complete oxidation, and, moreover, the density of the material used subsequently for filtration is insufficient to prevent the passage of the collodial fine ferric hydroxide. This disadvantage is obviated by the manganese Permutit filter. By means of the fine granular manganese oxides percolating through the whole filtering material, subsequent oxidation is promoted in the filter, while at the same time a very compact but pervious mass is formed, which retains the separated hydroxide.

As already mentioned at the commencement of this section, the oxygen contents of the manganese filter last only a certain time, and when the filter is exhausted must be renewed by treating the Permutit with potassium permanganate solution.

In order to extend as much as possible the intervals between the regenerations and to maintain the oxidizing power of the filter as long as possible, a highly diluted solution of potassium permanganate may be supplied in the form of drops to the water in the suction piping of the pump. This addition is, however, so small that an actual chemical influence on the iron contained in the water is out of the question. The addition has more particularly for its object the production of a fine col-

loidal precipitation of manganese hydroxides, which causes the iron itself to separate for the greater part. In this way, the iron sludge separates out mainly on the uppermost layer, and can be removed by backward flushing.

Under such circumstances the contents of oxygen in the filter lasts for a longer period, so that the filter need not be regenerated for a considerable time. From time to time sludge which has collected in the filter must be removed. Should a trace of manganese remain in the water due to the supplying of potassium permanganate, it is entirely removed by the Permutit, as will be readily understood. A layer of marble is provided above the Permutit for the purpose of combining with the acids, carbon dioxide and sulphuric acid, which are liberated as the iron is precipitated. By neutralizing the acids with lime, preferably marble, the hardness of the water is generally increased by 1 to 2 degrees, and afterwards removed by passing through a sodium Permutit filter.

We wish, in the following, to sum up the advantages which our process of iron elimination possesses over other known systems:—

(1) A Permutit installation is cheaper than a contact surface aeration plant, and dispenses with mechanical filters necessary to arrest the precipitated iron, and because the required amount of contact substance is less, less Permutit than gravel or coke being required, the cost of the installation as regards the filtering vessels is also less when Permutit is used.

(2) The separation of the iron is more perfect in a Permutit installation than in an aeration and gravel filtering installation.

(3) The working expenses are, in the case of Permutit, less than when contact surface aeration plants are employed. If a plant of this nature is to work properly, it must be well filled up with sludge. After the cleansing, its active power to remove iron is comparatively low, and it takes some little time before it is again active or in working order. If the contact mass and following mechanical filters are filled up with sludge, the excess of pressure in the filter is considerable, being far higher than in the Permutit filters. The water must, therefore, be constantly forced against a higher pressure. The high pressure in contact filters is accounted for by the fact that the specific gravity of gravels is higher than that of Permutit.

(4) Whereas ordinary quartz sand, coke, burnt clay and the like form physical combinations with iron compounds, so that the iron can only be removed from those materials by acids, and the iron readily causes a complete caking and cementing of the contact and filter materials, the separated iron compounds are easily loosened from the Permutit, and form with it no chemical compound which would give rise to a cementing of the filter material.

(5) In order to efficiently remove the iron, large quantities of air must be introduced into the iron-removing apparatus. Even when one need not have much fear of the infection by the air, it is, nevertheless, necessary when

gravel contact filters are used to see that the air is carefully filtered, in order that quantities of dust and the like, which might reach the air-suction pipe, be kept away from the water. When Permutit is used, the oxygen required for the removal of iron is introduced, not in the form of air, but in the form of permanganate. The permanganate solution used for the regeneration is in a concentrated form, and is a strong germicide. This solution is employed in concentrations of 1 in 30 to 1 in 50. If during the regeneration injurious substances should get access to the filter they would then be rendered harmless in the regeneration itself.

(6) In the application of gravel contact filters the disinfection of the filters at determined intervals of time is necessary, but being troublesome is seldom carried out. In the Permutit process, however, each regeneration of the filter is accompanied by a disinfection of the same, so that in comparatively short intervals of time all germs which may have reached the filter with the water are killed in the regeneration.

The previously described mode of proceeding with the removal of iron from water applies also to a great extent to the removal of the more stable manganese from water. In this case, however, an essential circumstance must be taken into consideraton.

By the separation of the manganic hydroxide in the filter, filtering material is supplied in increasing quantities by the water itself. In this manner not only is the surface of the filtering material increased, but also

the chemical action, since the manganese sludge from the water is capable of oxidation, and upon treatment with potassium permanganate, of taking up oxygen.

It has been proved by experience that a filter charged with 10 cwt. of manganese Permutit, which was employed for removing manganese from water, supplied originally 175,000 gallons of pure water between each regeneration, and after the twelfth regeneration 530,000 gallons of water free from manganese.

Clarification and Preliminary Purification of Water

It has been already explained that many kinds of water occur in nature which in consequence of their chemical or physical constitution cannot be purified by simple filtration. It is unnecessary to repeat that water which has been softened by passing through sodium Permutit remains the same, that is, if the crude water was naturally colored, the filtrate will also be colored. For this reason it is very difficult to remove iron from water, when combined with organic matter.

In such cases, it is absolutely necessary, when perfectly clear water is desired, to resort to a preliminary clarification.

The most suitable material for the clarification of water is aluminum sulphate, which is decomposed by hydrolysis into aluminum hydroxide and sulphuric acid. The jelly-like colloidal constitution of the hydroxide forms a coagulent which effects the removal of turbidity and coloring matters from the water during precipitation, and the production of a filtrate of crystal-like clearness. The sulphuric acid, liberated, combines with the temporary hardness of the water. The carbon dioxide which has been liberated remains dissolved in the water, from which it may be removed by passing the water over a layer of marble.

With regard to the quantities of aluminum sulphate which are to be used, a preliminary test should be resorted to as a guidance. Equal quantities of water are always mixed with specified quantities of aluminum sulphate solution, the formation of a precipitate, and also the time within which the jelly-like precipitate is formed, being noted. The smallest quantity of aluminium sulphate which, during a determined time of from 1 to 3 hours, suffices to make the water clear, is a criterion for the employment of the precipitating agent on a large scale.

We have endeavored, in what precedes, to give a short extract of our experience as regards water purification by the employment of artificial zeolites. As in the case with every new process, the present one was regarded with distrust and—apart from other motives—had to battle with prejudice. The further development of the process as exploited by us, is the best refutation of the objections raised against it; the results already obtained having exceeded expectations, and give great promise for the future of the Permutit process, and, as many eminent scientists say, will completely revolutionize the treatment of water for all purposes.

PERMUTIT IN THE TEXTILE INDUSTRY

zero
NO
HARDNESS
water

THE PERMUTIT COMPANY
30 EAST 42ND STREET
NEW YORK

Permutit in the Textile Industry

THE prime requirement of the Textile Industry is an abundant supply of pure water. The water must be clean, that is to say, free of suspended matter, but further than that it must also be soft.

The purest and only absolutely soft water in nature is rain-water. Unfortunately, rain-water can never be collected in quantities sufficient to serve even a small textile establishment, and hence recourse must be had to other supplies—rivers, ponds and wells. River and pond waters are frequently turbid as well as hard, while well waters generally contain harmful salts in solution in sufficient amount to be objectionable.

The dissolved salts which are harmful in textile processes are the salts of lime, magnesium and iron. The suitability of any water for textile purposes is in inverse proportion to the lime, magnesium and iron present—the more of these, the less suitable is the water to the delicate requirements of scouring, bleaching and dyeing.

Thus it happens that the great textile centers of the world are located in those favored spots where clear, soft water is to be had in abundance.

In England the wool industry is almost wholly concentrated in Yorkshire with Bradford as a center. The water of this region, as natural waters go, is fairly soft, and this consideration, perhaps more than any other, governed the location of the great wool-combing and wool-dyeing establishments there. The famous West of England cloth, so superior in its dyeing and finish, comes from a soft-water district. The cotton industry is in like manner concentrated around Manchester, because cotton manufacturers have found that the waters of that district are less objectionable for the dyeing of the cotton fabrics.

The great silk houses of France are to be found in Lille and in Lyons, where the comparative absence of lime and magnesium salts from the natural waters make these regions more suitable for the location of silk mills than any other in France.

Exactly the same thing is true in the United States. New England has long been favored by the Textile Industry for the reason that New England surface waters are generally soft. The Merrimac River, on which are located the great textile towns of Lowell and Lawrence, affords one of the softest natural water supplies in the United States.

The American silk center is Paterson, located on the Passaic River, which furnishes an abundant supply of comparatively soft water.

Softening "Soft" Water.—In spite of the advantages enjoyed by manufacturers in these regions owing to their favored location, the exigencies of the delicate textile process have compelled the manufacturers even in soft-water districts to correct, as far as possible, their relatively good water.

Formerly a water of say 3 or 4 degrees of hardness could not be treated because the so-called lime-soda process, the only one then known, could not produce a water softener below that point. A number of years ago the Permutit process of water softening by filtration was evolved by Dr. Robert Gans, a leading German chemist. This process not only discarded the old time cumbersome precipitating tanks and the obnoxious caustic chemicals required, but was able to remove the last trace of lime and magnesium from every water. Thus a water of zero hardness, as soft and as neutral as rain-water, was available for textile purposes.

In Europe Dr. Gans' discovery was hailed as the greatest step forward in the textile industry in twenty-five years. Manufacturers whose water supplies were already softer than could be produced by means of the

old precipitating systems of water softening, have been able by the installation of Permutit Filters, to extract the last few degrees of hardness which, nevertheless, were a source of trouble and expense in their mills.

Thus in Bradford, England, the largest and most important wool combers have installed Permutit Softeners to remove the 3 degrees of hardness in the natural Bradford water. In Lyons, Gillet et Fils, and other of the leading houses of that silk center, have installed Permutit to get rid of only 1 degree of hardness.

In the United States the leaders of the silk-dyeing industry in Paterson have installed Permutit to eliminate the 3 degrees of hardness of the Passaic River water.

That the benefits derived from the complete softening of even so naturally soft a water as the Passaic River affords are real and great is amply proven by the fact that one of the largest silk dyers in Paterson, after a two years' trial, has now doubled his Permutit installation, which was already a very large one. This point is made all the more apparent when it is considered that 1½ pounds of soap are destroyed per 1,000 gallons for each degree of hardness of the raw water. Thus water of 3 degrees hardness will destroy 4½ pounds of soap for each 1,000 gallons of water that come into contact with the soap. When soap costs six cents per pound this loss is twenty-seven cents per thousand gallons, an item which will run quickly into money in any mill.

Soap-Destroying Property of Hard Water.—The soap-destroying property of hard water may be regarded as the basis of almost all the trouble caused by a hard water in textile mills. The initial step in almost every case in the handling of silk, cotton and wool involves the use of soap in boiling off and scouring. In that initial step a hard water will produce effects the result of which will be felt even after the fabric is in the hands of the ultimate wearer.

If soap is dissolved in a water containing lime and magnesium, the lime and magnesium combine with the fatty acids of the soap, making oleates and streates of lime and magnesium which are insoluble and extremely sticky curds. These curds falling on the fibers, yarns or fabrics form so-called soap spots which can never be washed off, give a harsh feel to the goods, and are a cause of spotty dyeing and dull finish.

The Silk Industry

The turning out of uniformly high-class silk goods is a practical impossibility where the water available for the process contains even only a very small degree of hardness. Hard work and eternal vigilance will keep the quantity of goods spoiled by uneven dyeing and the other ill effects of a hard water at a minimum, but will never completely eliminate this loss. Hence the silk mill, for the sake of the quality of the product as well as for economy in operation, must have the softest water possible for every step of the process.

Soaking.—Raw silk before winding is subjected to a soaking process in a strong solution of castile soap and neat's foot oil to give it the necessary softness and pliability for the winding operation. If the soaking solution is made in hard water, the lime soaps are precipitated in it and mat the fibers, making them exceedingly difficult to wind. Permutized water, absolutely free from lime and magnesium, on the other hand produces perfect saponification in the soaking solution. The silk yields readily to the soft water and comes from the solution in a well-preserved state of pliability. No lime soap specks can be formed to stick to the fibers and afterwards cause the silk to reharden. Finally, Permutized water will materially quicken the soaking process.

At the throwing plant of an important silk cloth

weaver, located in New York State, the water for the soaking solutions is taken from a Permutit Softener installed primarily for treating the boiler supply. The superintendent, a man with more than twenty years' experience in silk throwing, says that the use of Permutized water has brought about an improvement that could not have been conceived beforehand. Another important silk throwster in the Middle West was so pleased with the results of a year's experience with Permutit that he has doubled his installation.

Degumming.—In the degumming, or boiling off, soap again enters prominently in the process, with the important difference that boiling off calls for greater quantities of soap and water than the soaking. Consequently, all of the ill effects of soap dissolved in hard water are intensified in the degumming operation. The danger from soap specks is much greater in that the precipitated lime soap sticking to the silk frequently first discolors it, then partially decomposes and finally often causes the silk to crack.

The saving of soap in the dye house using Permutized water is tremendous. The saving is, of course, in proportion to the hardness of the raw water, but a large silk mill using water of 9 degrees hardness has reported that the soap saving alone paid for the entire installation in less than two years. Any dyer using a water containing even as little as 5 degrees of hardness can readily appreciate this. At a dye house using Brooklyn city water, not quite 4 degrees hard, when the boil-off bath is prepared the lime soaps cover the surface of the water in a scum which must be removed as far as practicable by skimming. This takes time, during which the process is at a standstill, but the wages of the men standing idly waiting go on just the same. With Permutized water the soap goes quickly into solution, and as there is no lime or magnesium, there is no sticky, curdy scum, and there is no time lost in skimming.

Feel.—The precipitation of the lime soap on the silk renders the goods noticeably harsh to the touch. Permutized water on the other hand leaves the goods delightfully soft to the touch. The proper hand and luster is imparted in the processing of piece dye silks only when an absolutely soft water is used.

Weighting.—The extremely harmful effects of the lime soaps which adhere to the silk in spots and streaks are pronouncedly felt in the operation of weighting silk. The sticky lime soap prevents the weighting solution from coming uniformly into contact with the silk. Wherever the fiber is overlaid with the lime soap the tin cannot fasten itself to the silk, which causes the "hungry spots" that make the dyer complain, and rightly too, because since the tin acts as a mordant or fixitive the "hungry spots" will always show up duller than the rest of the fabric, and give the unevenly dyed appearance that is the bane of every dyer. This cause of uneven dyeing disappears, of course, in dye houses using Permutized water, which is free of the least trace of lime and magnesium.

Not the least of the objections to the use of hard water in weighting is the actual loss of tin that always occurs when the silk has been processed in water containing lime and magnesium. The curdy deposits on such silks are, as has been already pointed out, oleates of lime and magnesium. The chloride of tin of the weighting solution reacts on these oleates, producing, partially but noticeably, oleates of tin, which are, of course, useless for weighting and increase its cost by an appreciable percentage. The importance of this wastage may be realized from the oft-made statement that the mud at the bottom of the Passaic River in certain places runs as high as 5 per cent. of tin—all lost from the dye houses.

Dyeing.—When it comes to the actual dyeing of the silks, either in the skein or in the piece, the results obtained with Permutized water are truly remarkable when compared with what the raw water produces.

Permutized Water Is Non-Caustic.—In the first place the treated water from the Permutit Water Softener contains no free alkali; it is absolutely neutral to phenolphthalein. This is in wonderful contrast to the treated water from lime-soda water softeners, which are always distinctly caustic and must be carefully neutralized before use in the dye house. In a lime-soda softener installed in a knitting mill in the South there are six large treating tanks. Four of these are for treatment with lime and soda, while the other two are for the neutralization of the causticity of the treated water with sulphuric acid. Thus the investment is, by the need of neutralizing the caustic-treated water, increased by one-third, and the cost of treatment by even more than that, for the entire quantity of water going to the dye house must be repumped, and in addition to that there is the cost of the acid and the extra attendance required.

Were this a Permutit installation, the treated water would be non-caustic and the correcting after treatment could be entirely done away with.

The effect of a caustic water when acid dyes are used is to break down the dye stuff, due to the capturing of the acid radicle of the dye by the alkali of the caustic water. This will either cause the precipitation of the color as a tarry mass, or else the complete change of the character of the dye, so that instead of a blue, for instance, a green is produced.

Brightening of Colors.—One sure effect of the use of Permutized water for silk dyeing is the brightening of the colors, and the most gratifying feature of this, to the dyer, is the fact that the brighter colors are pro-

duced with a less amount of dye stuff than the "sad" colors made with hard water required. Colors now are just about as expensive as the dyers care to see them. Economy in the use of dye stuffs thus becomes of prime importance, and the saving effected by Permutit in this respect will generally be found to equal, if not to exceed, the soap saving. Instances are on record where the saving on dye stuffs paid the capital charges as well as the operating cost of the Softener, leaving the soap saving absolutely clear profit to the manufacturer.

Improvement of Product.—Great as are the savings in actual money in the soap and dye stuff bills, those savings do not represent the greatest value of the Permutit Softener to the silk manufacturer.

The markedly great improvement in the quality of the product turned out by the silk mill after the installation of a Permutit Softener is, perhaps, the greatest single reason for Permutit's marvelous success.

Silks of all kinds processed with Permutized water, whether in the piece or in the skein, are delightful to the feel and beautifully, evenly and brilliantly dyed. Uneven dyeing disappears, because soap spots and streaks have disappeared and because there is no longer possibility of reaction between the treated water and the dye stuffs. Colors are brighter, and accurate matching of the most delicate shades is always possible.

The favorite excuse for spoiled goods—hard water—is removed, and spoiled goods practically disappear. The impelling reason for the installation of a Permutit Softener by one dyer was the fact that spoiled goods were costing him eight thousand dollars a year. Now his customers, instead of sending back goods, have nothing but praise for the quality of dyeing being done for them.

Washing Off.—A water free of lime and magnesium is, perhaps, as desirable in the washing off of dyed piece goods as it is in any other step of the process. When

a hard water is used for this purpose, great trouble is frequently met with through the discoloring of the selvages of the pieces. This discoloring is in the case of silk almost always a "white list"—a lightening of the color due to the fact that the lime and magnesium act as a resist to the silk dyes.

The Cotton Industry

Cotton bleachers and dyers show a decided preference for soft water for their processes. In this country this is shown by the location of the bulk of bleacheries and finishing mills in New England, where comparatively soft waters abound, instead of in the South, where, although many spinning mills are to be found, bleacheries and dye houses are rare.

Boiling Off.—The first operation of cotton bleaching, boiling off, requires soft water for very much the same reasons that soft water is used in stripping silk. The resin soap used for the preliminary boiling where the lime boil is used, reacts like other soaps with the lime and magnesium salts of a hard water. Instead, however, of making stereates or oleates of lime and magnesium, as do the other soaps, resin soap makes resinates of lime and magnesium, which are just as insoluble and even more sticky. These resinates precipitated on the cotton yarns or cloth give rise to the same kinds of trouble as the soap spots cause with silk. The finish of the goods is deteriorated and satisfactory dyeing or printing subsequently is made difficult.

Lime, caustic soda, soda ash and silicate of soda, the chemicals most frequently used for the boil-off, all react on the magnesium and lime salts in the raw water, causing their precipitation in the kiers as hydrates, carbonates or silicates. It stands to reason that an excess of chemicals, over and above that required for boiling off the cotton, must always be put in the kiers with a hard water. When Permutized water is used there is

no such waste and the cost of boiling off is reduced accordingly.

The presence of the precipitated carbonates and silicates of lime, which are inert as far as the boil-off is concerned, is far from beneficial to the process, and increases the souring required subsequently. Too much souring is harmful in that it tends to tender the fiber.

Improvement of "Feel."—Cotton yarns processed with Permutized water have a much finer feel than they can possibly have when they have come into contact with hard waters. The effects are quite remarkable, ordinary yarns having a feel like a combed Sea Island. The knitting and hosiery mills in this country which have already installed Permutit Softeners are highly pleased with the results they are obtaining. The waters treated for such purposes vary from 8 to 12½ degrees, but after passing through the Permutit are all of uniform zero hardness.

The non-caustic character of the Permutized water becomes of great value in this connection. A caustic water, such as the treated water from a lime-soda softener, must be neutralized with acid. The difficulty and, in fact, practical impossibility of doing this perfectly brings about the danger of tendering the yarn, and thus interferes with the spinning of the fine yarns possible only with Permutized water.

Mercerizing.—In mercerizing, the chemicals used, strong solutions of caustic soda or of zinc or cupro-ammonium, also cause the precipitation of the lime and magnesium salts in the same manner as already described as taking place in the kiers.

Electrolytic Bleaching.—Cotton manufacturers using the electrolytic method of generating chlorine for bleaching purposes are able to operate Permutit Softeners practically without any expense for up-keep.

This extremely favorable condition is brought about by the fact that the by-product of the Permutit Softener is a clear solution of calcium and magnesium chlorides. The process of regeneration of the Permutit Softener is described on pages 5 and 6 of The Permutit Company's "Blue Book," so it need only be briefly stated here that the exchange which takes place between the calcium and magnesium, absorbed by the Permutit during the passage of hard water through the Softener and the sodium of the salt solution, converts the latter into a solution of calcium and magnesium chlorides. For the electrolytic process, the cotton manufacturer buys common salt, sodium chloride, and his electrolyte is a solution of common salt, which is broken up by the electric current in the cell, with the liberation of chlorine gas. Now if the common salt solution is first passed through a Permutit Softener for the purpose of regenerating the latter, the chlorine contents of the salt solution are not affected in any manner by the conversion of the latter into a solution of calcium and magnesium chlorides, and if this last solution is used for the electrolyte in the cell, just as much chlorine gas will be generated as would have been produced with the original common salt solution.

In this way the cotton manufacturer can install a Permutit Softener and obtain the numerous advantages of the perfectly soft water practically without any increase in his annual expenses.

Peroxide Bleaching.—For peroxide bleaching, the presence of lime and magnesium in the water is troublesome, but the presence of iron in any form is fatal.

The oxygen developed by the peroxide precipitates the iron on the goods, causing always a very inferiorly bleached product and frequently causing the formation of deep rust spots which completely ruin the goods.

The Permutit Company has several processes for removing dissolved iron from waters, these processes

being adapted to the varying forms in which dissolved iron is found in raw waters. All of these processes are of high efficiency and wherever installed will put an end to the troubles occasioned by the iron. There are a number of these Permutit iron removers in this country giving satisfactory results to the purchasers. At one cotton underwear and hosiery mill in Illinois, before the Permutit installation was made, a serious condition existed due to the presence of both iron and lime in the water. Eight months after the installation of a Permutit iron remover and a Permutit Softener this mill reported savings from the free-from-iron-zero hardness water delivered by the Permutit, which had practically already paid the entire cost of the plant. They quite naturally feel sufficient good-will to recommend the Permutit Softener very highly.

The Woolen Industry

Water enters so largely into practically every step of the process of manufacture of woolen goods that the character of the water supply becomes the most important single factor in the production of woolens. Woolens of the highest class cannot be produced with waters of even comparatively little hardness, so that the quality of the product of any woolen mill is very definitely governed by the quality of the water available.

Scouring.—The faultless scouring of wool is the keystone of the entire process of manufacture of woolen goods. When a water containing lime and magnesium is used in scouring, the gray-colored oleates formed by the soap destroyed in such a water give a dingy, dirty appearance to the wool and impart to it a sticky feel which is injurious in all subsequent operations.

The soap-destroying effect of a hard water used in scouring greatly increases the cost of the process. Fine qualities of wool are best scoured with well-made soaps

free of alkali. Generally speaking, from 3 to 5 pounds of such soap per 100 gallons are required for the scouring bath. A water absolutely free of lime and magnesia will produce first-class wool with 3 pounds, while waters of even moderate hardness will often require more than 5 pounds. The saving when Permutized water is used for scouring is, therefore, tremendous. One case is on record of a wool scourer in the Bradford District in England who states that he saved $15,000 in one year on soap-saving alone. The cost of the Permutit installation in this mill was $14,000, so that it was more than paid for in one year.

Smaller mills always achieve this saving in proportion to the amount of soap that was used with the hard water. In this country the minimum saving which has been reported was 30 per cent. of the soap bill by a worsted mill in the Middle West. Other savings reported run as high as 50 per cent., and the repeated statements from these owners that they could not now get along without their Permutit Softeners are readily believable.

Soap Spots.—The oleates, the sticky lime and magnesium soap curds, interfere in every subsequent manipulation of the wool. Carding machines handling wool covered with soap spots have their scrapers rapidly clogged up, causing a loss of time in clearing them. When such wool is stored, the soap spots decompose and impart a very unpleasant odor to it which tends further to lower the quality. When this wool is turned into yarn, there is a poor yield, the yarn is uneven and is not easily drawn off from the spools later on. The soap spots make dirty, unsightly spots in white goods, and cause lighter or darker splotches and streaks in the piece, according as the soap spots attract or repel the color in the dye bath.

These defects completely disappear when a Permutized water, which cannot cause the deposit of any

oleates, is used in the scouring. Furthermore, comparative tests show that higher numbers can be spun from a wool free from oleates, such as Permutized water alone produces, which is, of course, a distinct advantage to the spinner.

Softer Feel.—The effect of the soap spots on the feel of the goods is a markedly disagreeable one. The soft, elegant feel so much desired is well-nigh impossible when the wool is processed in hard water. The wool fiber is exceedingly susceptible in this respect, and the change in results obtained where Permutized water is substituted for even a very moderately hard raw water is very marked. Another one of the scourers in the Bradford District has stated that after the installation of Permutit Softeners a regrading of the wool was possible, with a gain of 10 per cent. in the higher grades and a corresponding reduction in the lower ones.

Mordanting.—Raw waters containing the carbonates or bicarbonates of lime and magnesia cannot be used in the usual mordanting processes. This is because the acid salts used as mordants react on the lime and magnesia carbonates and bicarbonates, thus wasting the mordant and precipitating lime or magnesia in the bath. Dyers always are compelled to neutralize such waters with an acid which is troublesome and also a source of added expense. The attempt at neutralization is seldom, if ever, a perfect one, and consequently the mordanting process itself produces perfect results only with great difficulty with such waters. The difficulties and waste disappear when the absolutely soft Permutized water is used.

Bleaching.—Wool scoured with Permutized water shows a noticeable improvement when compared to the hard-water product. The white color obtained with the former is strong and brilliant, while the latter leaves a

grayish white. Bleached combings of the former have the much desired soft feel and a beautiful luster.

Dyeing.—In the dye baths the presence of lime and magnesium salts is frequently the cause of inferior dyeing as well as of serious loss of dye stuffs. The harmful effects of these salts vary with the character of the color employed.

Coal-tar dyes, whether basic or acid, are harmfully affected by hard waters. The basic dyes are especially unsuited for use with such waters, because the lime and magnesium salts react with these dyes, precipitating the color in a tarry mass that sticks to the fiber and causes the defect of "rubbing off." The acid dyes cannot be used with a carbonate water, unless neutralized with an acid, for the same reason mentioned in the case of the ordinary mordants.

Varying with the character of the dye, the lime and magnesium salts act as detergents or mordants, with consequent tendency to inaccuracy in matching shades and in producing uneven dyeing. Where they act as detergents, colors are wasted in an attempt to overcome their "sadding" effect, whereas where they act as mordants, they affect harmfully the color lakes formed and make it exceedingly difficult to obtain even shades.

It is still disputed whether or not lime should be present when dyeing blacks. Good evidence is available against the value of the lime, but even in the case where its presence is desired, it stands to reason that the best practice is to add correctly proportioned amounts of lime, if such be necessary, to the bath prepared with Permutized water. In this way the danger of the use of an excess of lime, where the raw water is of varying composition, is eliminated.

Washing Off.—No matter what the effect on the dye stuffs of the lime and magnesium salts, it is certain that the washing off of piece goods after dyeing or mordant-

ing should always be done with Permutized water. Otherwise the deposition of the salts in the selvages of the goods, due to the evaporation of the water, will give rise to "white lists" or "dark lists," according as the salts act as mordants or detergents with the particular dye stuff used.

Conclusion.—It is a fact that the indorsement of owners of Permutit Softeners is one of the greatest factors in the increase of Permutit installations. Their evidence of the value of Permutized water in effecting savings and bettering product is incontrovertible because it is first hand and disinterested evidence. The duplication of the Permutit installations frequently made in mills where the value of the system has been shown is evidence also that more business is the result of the bettered product due to Permutit.

To sum up, the finished product in every case, whether silk, cotton or wool, is of much higher grade, and hence much more readily merchantable when Permutized water "as soft as rain-water" has been used for every step of the process. Every textile manufacturer, no matter where located, can now equal the product of the world's most famous mills by obtaining for himself what used to be an advantage strictly of location—a suitable and perfect water supply by means of the Permutit Water Softener.

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